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Evolution of the Mayo Kebbi region as revealed by zircon dating: An early (ca. 740 Ma) Pan-African magmatic arc in southwestern Chad

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Abstract

The Mayo Kebbi region in SW Chad is part of the NNE-SSW trending Neoproterozoic Central African Fold Belt (CAFB) and is made up of three calc-alkaline granitoid suites emplaced into a metavolcanic–metasedimentary sequence. The first suite is represented by mafic to intermediate rocks (gabbro-diorite and metadiorite) emplaced between 737 and 723 Ma during early Pan-African convergence. The second consists of the Mayo Kebbi batholith and includes tonalites, trondhjemites and granodiorites, emplaced during several magmatic pulses between 665 and 640 Ma. The third suite includes porphyritic granodiorite and hypersthene monzodiorite dated at ca. 570 Ma. The Mayo Kebbi domain extends southward into Cameroon and is interpreted as a middle Neoproterozoic arc stabilized at ca. 650 Ma. This study also revealed a diachronous evolution between Mayo Kebbi and western Cameroon (e.g., the Poli region). The overall evolution of this part of the CAFB is interpreted as the result of successive development of magmatic arcs, since ca. 740 Ma, and tectonic collage of three different domains (Adamawa-Yade, Mayo Kebbi, and West Cameroon) which, after suturing, were intruded by post-collisional granitoids (<600 Ma).
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1. Introduction

The Pan-African history of the mobile belt of central Africa (Bessoles and Trompette, 1980) resulted from its south-western insertion and collision, at ca. 600 Ma, between the Congo and West African cratons (Castaing et al., 1994; Toteu et al., 2004). The most striking evidence for this evolution is the presence of crustal-scale strike slip shear zones, some of which juxtapose crustal segments of various ages and which are oriented N–S along the eastern border of the West African craton and NE–SW on the northern margin of the Congo craton. However, this simple large-scale model appears less obvious in regions far away from the craton margins, probably due to interference of tectonic structures and to the presence of early-stabilized microblocks (e.g., eastern Hoggar; Caby and Adreopoloulos-Renaud, 1987). Further difficulties are the lack of exposures now hidden by Cenozoic sediments and the fact that some of these regions such as Tibesti, southwestern and eastern Chad (Darfur massif), and northern Central African Republic (CAR) are poorly surveyed, and no reliable isotopic data are available. To fill this gap, we have undertaken an isotopic reconnaissance survey of southwestern Chad in order to compare and correlate

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this region with northern and central Cameroon. We report Pb–Pb and U–Pb zircon ages (conventional dissolution and evaporation technique) and whole-rock Sm–Nd isotopic systematics of granitoid rocks, which constitute the major rock units of the region. Our results favour a model of diachronous Pan-African tectonic evolution between SW Chad and northern Cameroon.

2. Geological setting and previous geochronology

From previous work (Schneider and Wolff, 1992; Kusnir and Moutaye, 1997; Kasser, 1995; Doumnang et al., 2004) it is likely that southwestern Chad (also known as Mayo Kebbi region) is the NE extension of the Poli terrain in northern Cameroon (Fig. 1). Phanerozoic platform sediments cover most of the Precambrian basement of the region, which is dominated by the Mayo Kebbi tonalitic batholith, emplaced into a medium to high-grade gneiss–amphibolite complex (Schneider and Wolff, 1992). The region is also characterized by two NNE-SSW belts of low- to medium-grade schists (the Zalbi and Goueigoudoum Groups), of which the Zalbi Group was thrust eastward across the gneiss–amphibolite complex and the Mayo Kebbi batholith (Kasser, 1995). All these rock units are intruded by post-tectonic granitoids (Zabili granite, Pala hypersthene monzodiorite and porphyritic granite).

The gneiss–amphibolite complex as defined by Schneider and Wolff (1992) is exposed east of the Zalbi Group and is also found as numerous xenoliths within the tonalite batholith. This complex comprises hornblende-biotite gneisses interlayered with banded amphibolites; the presence of calc-silicate layers associated with amphibolite suggests that part of this unit is of sedimentary origin. According to Kasser (1995), and our field observations, this complex also includes meta-plutonic rocks consisting dominantly of metadiorites that are associated with minor gabbros, norites, and peridotites. Kasser (1995) used the term "mafic to intermediate complex" as equivalent of the gneiss–amphibolite complex of Schneider and Wolff (1992). However, because the gneiss–amphibolite complex is a metamorphosed volcano-sedimentary or sedimentary sequence, we restrict Kasser's terminology to the meta-plutonic rocks associated with the supracrustal sequence.

At the scale of Fig. 1, it has not been possible to distinguish the sedimentary sequence from the associated plutonic rocks. Field relationships document that the metadiorites intruded the amphibolites, and both were affected by polyphase deformation during amphibolite-facies metamorphism. However, this penetrative deformation was not observed in the associated gabbro-diorites, which display only local shearing. This suggests that the metadiorites are pre- to syntectonic, whereas the gabbro-diorites are late tectonic or, alternatively, that both rock-types underwent heterogenous deformation which was more intense in the metadiorites. The polyphase deformation comprises an early flat-lying foliation with early E–W lineations that were later transposed by upright folds with N–S to NE–SW axial plane foliations and horizontal axes.

The Zalbi and Goueigoudoum schists comprise clastic and epiclastic rocks, interlayered with felsic to mafic metavolcanics. The tholeiitic geochemical signature of the metavolcanic rocks suggests their development in an island arc and/or back arc setting (Kasser, 1995; Doumnang et al., 2004). The Zalbi Group is characterized by a N–S to NNE–SSW striking foliation containing a steeply plunging (>50°) E–W stretching lineation with kinematic markers indicating top-to-the-east reverse movement. This structure is interpreted to indicate thrusting of the Zalbi Group (Fig. 1) across the gneiss–amphibolite complex and the Mayo Kebbi batholith (Kasser, 1995). According to this author, tectonic lenses of ultramafic rocks demarcate a nappe front.

The Mayo Kebbi batholith covers more than 50% of the Mayo Kebbi region and is exposed in its central part. It is composed of tonalites, trondhjemites and granodiorites containing large xenoliths of polydeformed banded amphibolites. The Mayo Kebbi batholith did not undergo pervasive deformation; however its southeastern border is highly sheared and was metamorphosed under low-grade metamorphic conditions close to the sinistral Tcholliré shear zone (Pinna et al., 1994). The main rock-type is a tonalite displaying a steeply dipping magmatic foliation parallel to the regional structure and underlined by mafic minerals and xenoliths. Within the batholith, sinistral and dextral shear zones are also observed, suggesting that the batholith underwent heterogeneous deformation. Some tonalites are deformed and retrogressed (protomylonite of Vidal et al., 2004), whereas others were deformed under low-grade conditions and yet others are undeformed, suggesting that the emplacement of the batholith was broadly syn- to post-tectonic relative to the deformation observed in metadiorites and xenoliths of amphibolite. The age of deformation of the Mayo Kebbi tonalites is given by an age of 639 ± 20 Ma obtained on the syntectonic Landou granite (Pinna et al., 1994, see below). Most of these plutonic rocks are calc-alkaline in composition with negative Nb–Ta anomalies, indicating a subduction-related magmatic arc setting (Kasser, 1995; Doumnang et al., 2004). The post-tectonic granitoids comprise the Pala porphyritic granodiorite and the hypersthene monzodiorite, among others, both of calc-alkaline composition, and the Zabili uraniferous granite.

Few geochronological data are available for the Mayo Kebbi region. Non-conclusive whole-rock Rb–Sr ages of 538 ± 110 Ma and 683 ± 172 Ma were obtained on a diorite at the Chad-Cameroon border and on the Zabili granite (Kasser, 1995). However, in Cameroon close to the border with Chad (Fig. 5), whole-rock Rb–Sr isochron ages of 626 ± 15 Ma and 677 ± 40 Ma were obtained on the extension of the Pala batholith at Kaele (Lasserre in Bessoles and Trompette, 1980) and at Sinassi (Pinna et al., 1994), respectively. Furthermore, Pb–Pb minimum ages on single zircons (Pinna et al., 1994) were

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